Oil and Gas Development

The oil and gas fields in operation on the refuge may pose the largest contamination threats to the refuge.

The oil and gas fields in operation on the refuge may pose the largest contamination threats to the refuge. Currently, the KNWR is the only refuge in Alaska where commercial oil/gas production is permitted. The USFWS regulates surface operations, and the Bureau of Land Management (BLM) regulates subsurface operations. This section will discuss the two main oil/gas fields on the refuge, Swanson River Field (SRF) and Beaver Creek Field (BCF), major spills associated with these fields and additional potential contamination events/sources associated with oil/gas development. For general information about petroleum toxicity, please see Appendix A.

Swanson River Field

On July 19, 1957, Alaska's first significant oil reserves were struck at SRF in the heart of KNWR. Swanson River Field was Alaska's first oil/gas field, and its oil production was a major catalyst for Alaska's statehood. Since discovery in 1957, considerable oil exploration and development have occurred on the KNWR, resulting in numerous oil and hazardous material spills. It should be noted that environmental practices have changed considerably throughout the years, and when the SRF was established most of the United States's environmental laws did not exist. The following companies have been the operators of SRF: Chevron USA, Inc. from 1957 - September 30, 1986; ARCO Alaska, Inc. from October 1, 1986 - December 15, 1992; Union Oil Company of California (Unocal) from December 16, 1992 to present.

Jim Frates, Kenai National Wildlife Refuge Operations Specialist, at the Swanson River Field discovery well. USFWS Photo by Tiffany A. S. Parson.

The SRF is located approximately twelve miles north of Sterling, Alaska. A detailed description of SRF is summarized by James E. Frates (1999a), Operations Specialist for Kenai National Wildlife Refuge:

> *The Swanson River Field occupies approximately 12 square miles and includes the following: 30 miles of road, 60 well pads, seismic lines, 177 acres of building and storage areas, 5 residences, office and maintenance shop building, large compressor plant for gas injection, oil pumping station, 35 acres of gravel and sand pits, a solid waste disposal site, a pipeline complex from each well to 7 tank settings, 7 flaring stacks, a 6 inch crude and 12 inch gas pipeline from the field to Nikiski, two steel girder bridges over the Swanson River, two power lines crossing the river, a power line complex throughout the field, in addition to the main feeder line coming from Nikiski within the underground pipeline corridor.*

This section details some of the major spills and contamination events that have been reported at Swanson River Field from 1956 to April 2000. Most of the spill information from 1957 to February 1999 was taken from a report by Frates (1999b). An unabridged version of this report may be found in Appendix B. It is important to note that the number of *reported* spills may differ from the number of *actual* spills,

especially during the early years of oil/gas production. The refuge Annual Narratives report several instances where fires and spills apparently went unreported and were discovered by refuge staff at later dates. While a complete listing and discussion of all known spill events is beyond the scope of this assessment, a number of significant spills and contamination events are summarized in this section.

Major Spills and Contamination Events Reported at Swanson River Field

Flowline Break - 1961

In early 1961, a line break at well site 32-8 caused oil spray to reach the Swanson River (over 2,000 feet from the well head). This discovery, that oil reached the Swanson River, did not happen until the spring thaw occurred.

Diesel Fuel and Engine Oil Leak - 1963

This information was taken from the January-April 1963 Annual Narrative:

> *In spite of additional conditions imposed on the Unit Operator prior to completing construction of temporary access road and location…and continued checks during drilling operations, diesel fuel and engine oil escaped the sumps due to dike breaks and polluted the surrounding country side. Complete cleanup was demanded, but before equipment became available incessant winter rain flooded the frozen muskeg and carried off the pollutants depositing them elsewhere.*
> (page 29)

Contamination from Drilling Operations - 1968

This information was taken from the 1968 Annual Narrative:

> *During drilling operations at the Swanson Lakes Well #1, an adjacent pothole to the drilling pad was contaminated, as was the surrounding vegetative cover. Consequently, during an August inspection of Texaco's cleanup progress the refuge staff observed this pothole in a very contaminated condition. Considerable damage to surrounding timber and vegetation had resulted from the oil and caustic soda pumped into the pothole.*
> (page 41)

Flowline Break - April 18, 1969

A 4" flowline serving well 4-34 separated at the "Dressler Coupling," approximately 40 feet east of the Swanson River. The line was originally a low-pressure line; however, it was converted to high-pressure without reinspection of the coupling. The coupling failed, allowing crude to spray out and into the Swanson River. Because the line was shut in almost immediately, the quantity spilled was minimal (no estimate given). Three burlap absorbent booms were placed in the Swanson River (ice-packed at the time) between the spill site and the south bridge, and a vacuum truck was used to extract free product. By using the booms and vacuum truck, crude was prevented from flowing past the south bridge.

Compressor Plant Explosion - January 27, 1972

A 1984 nationwide environmental contaminant survey on refuges where oil and gas operations existed revealed the presence of polychlorinated biphenyl (PCB) compounds at SRF in soil samples

Reported Spills at Swanson River Field from 1957 to February 1999.

292 Reported Spills (7 spills/year average)

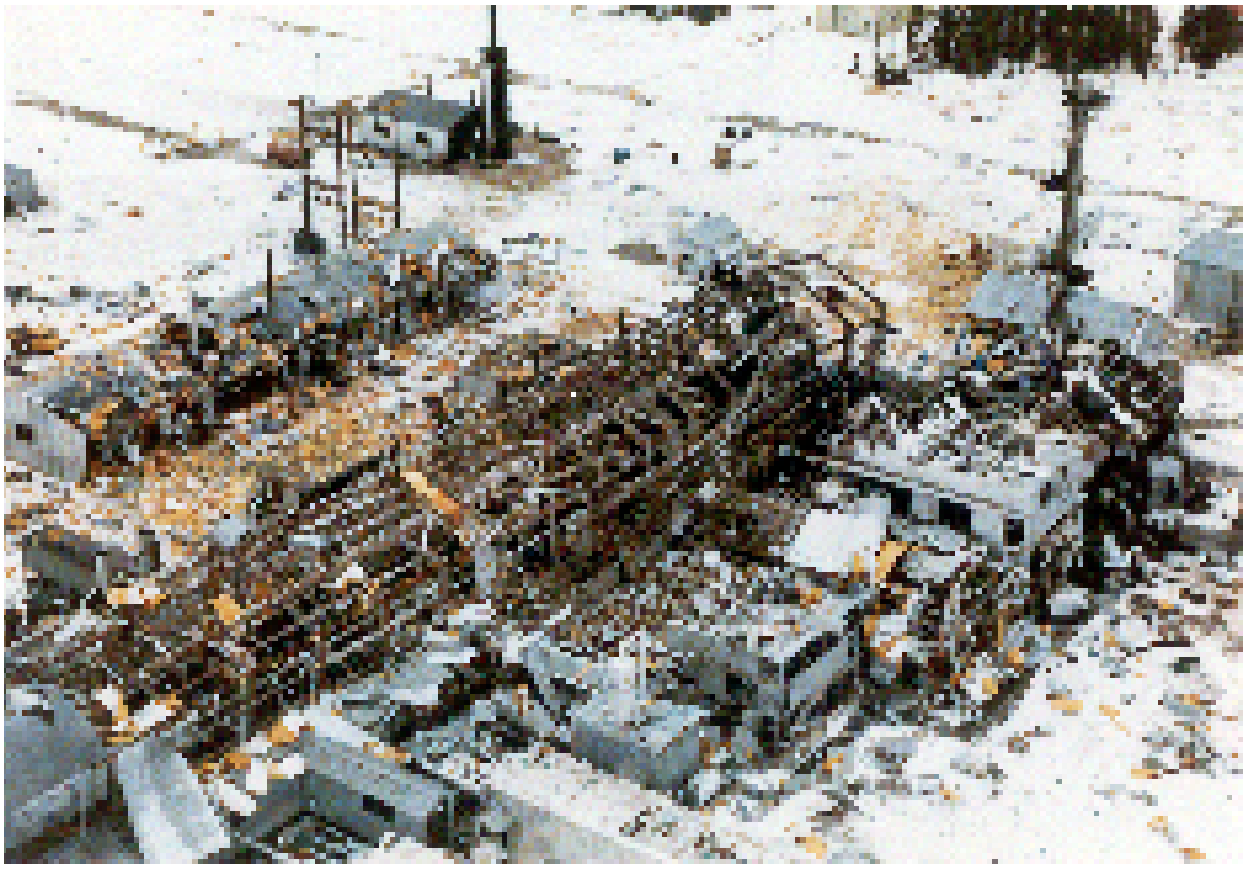
--35 gallons (gal) anti-freeze
--65 gal methanol
--85 gal hydraulic fluid
--100 gal solvents
--452 gallons diesel fuel
--2,213 gal triethylene glycol
--24,169 gal crude oil
--238,749 gal produced water
--unknown quantity of xylene released at Pipe and Supply Yard

Source: Frates (1999b)

within the road right-of-ways (ROWs). For general information about PCB toxicity, please see Appendix C. Preliminary sampling at SRF preformed on July 22, 1984 revealed PCB concentrations of 30 parts per million (ppm) in a road sample collected near the administration building and 10 ppm in a sample from the SCU 14-3 sump.

In 1983 and 1984, Chevron (then unit operator) had been permitted by the Alaska Department of Environmental Conservation (ADEC) and the U.S. Fish and Wildlife Service to spread oily gravel stored in the 14-3 gravel pit (SCU 44-4) on interior field roads for fugitive dust control. The source of the contamination was eventually traced to the storage site at the 14-3 gravel pit. Chevron used this pit since the 1970s to store crude-laced gravel excavated during spill cleanup operations. The source of the PCBs was further traced to gravel extracted (and stockpiled at the 14-3 site) from and around the compressor plant explosion that occurred in 1972 .

The source of PCBs (Aroclor 1248) was found to be a thermal inhibiting liquid used in the multi-stage compressor engines; it was released in and around the compressor plant during the explosion. From 1962 to 1972, Aroclor 1248 was used in the process heat transfer system at the compressor plant. Following the compressor plant explosion in 1972, Therminol FR-1 (Aroclor 1242) was used.



Compressor plant explosion at Swanson River Field on January 26, 1972. The compressor facility (still in operation) provided high-pressure gas for reinjection into oil producing formations, forcing crude to the surface. USFWS Photo by Richard A. Richey.

The PCB cleanup at Swanson River Field is estimated to have cost over $40 million.

By 1977, Therminol FR-1 was replaced with Therminol 66, which did not contain PCBs. However, testing in 1982 revealed residual contamination of 381 ppm Aroclor 1242 in the Therminol 66. Upon this realization, the fluids were drained, and the system was flushed. As of 1988, less than one ppm PCBs remained in the system (Metsker, 1988).

In 1985, Chevron agreed to proceed with cleanup operations under an "Order by Consent," with the USFWS, ADEC and BLM. The Consent Order triggered, what was at that time, the largest PCB remediation effort ever undertaken on federal lands (Crab Orchard NWR now has that dubious honor).

Chevron's consultant, Ecology and Environment, Inc., conducted site assessment and characterization studies in all areas within the field where known contamination existed. These sites were excavated, and contaminated material was hauled to a designated processing site at the 14-3 gravel pit.

In 1986, ARCO Alaska, Inc. (ARCO) took over as unit operator of the Swanson River Field. They assumed all cleanup liability previously imposed on Chevron under the Consent Order. On August 10, 1987 during PCB excavation activities around the foundations of the therminol heater building and compressor plant buildings A and B, high PCB concentrations and 2,3,6,7-tetrachlorodibenzofuran (TCDF) were discovered. PCB concentrations ranged from 8,000 ppm to 220,000 ppm. It is speculated that TCDF contamination resulted from incomplete combustion of PCBs from a fire at the therminol heater building on August 30, 1968.

PCB contaminated soils were excavated from several miles of road within Swanson River Field.

Site assessment and characterization continued as well as excavation of all sites where soil sampling indicated the presence of PCBs in excess of 12 ppm (Figure 3). ARCO entered into a contract with Ogden Environmental Services for the installation and operation of a natural gas-fired circulating bed combustor (CBC) to incinerate

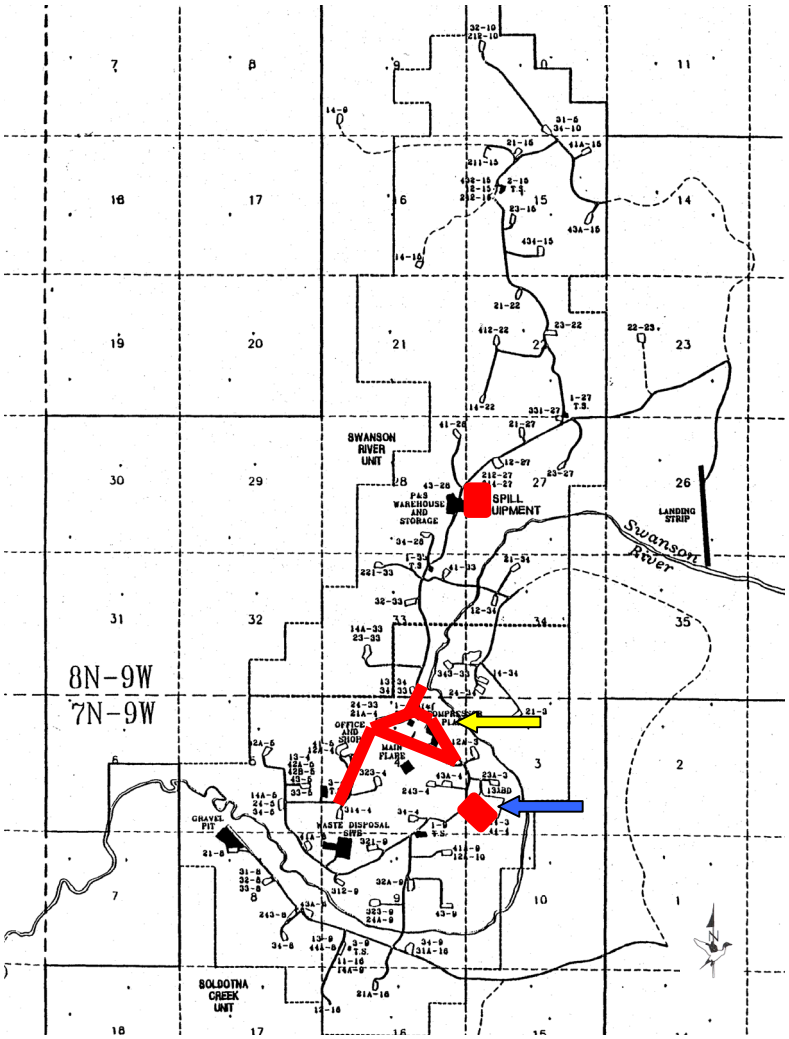
Circulating bed combustor. USFWS Photo by Robert A. Richey.

The circulating bed combustor operated from 1987 to 1992 and incinerated over 107,000 tons of PCB contaminated soils.

all contaminated soil that had been excavated throughout the field. Following EPA licensing and permit authorization, the CBC began operations in 1987. The CBC continued operations until the summer of 1992, resulting in the incineration of over 107,000 tons of contaminated soils.

The only known remaining PCB contamination is beneath the rebuilt compressor plant. Under terms of the Consent Order, remediation of this area has been deferred until the compressor plant is demobilized. Water samples are taken from perimeter monitoring wells biannually and analyzed for PCB compounds; all results to date have been negative, suggesting that this contamination has not migrated off-site.

Figure 3. Schematic of PCB Excavation Areas within Swanson River Field.



Areas in red approximate major PCB excavation areas; the yellow arrow (top) is pointing toward the compressor plant; the blue arrow (bottom) is pointing at the 14-3/44-4 site, where PCB contaminated soil was stockpiled from the compressor plant explosion and where incinerated soils were processed and spread.

All incinerated soils from the CBC were placed in a lined and capped disposal cell just to the west of the 14-3 site. In 1992, the area was covered with a layer of topsoil and seeded with a mixture of northern variety grasses.

Numerous technical reports were generated during this extensive project, and a listing of these reports can be found in the Bibliography and Literature Cited for this assessment.

Gas Blow Out - 1986

On December 12, 1986, field personnel noticed surface gas venting in several locations near well 44-8 (southwest of south bridge) in the extreme southern part of the field. Apparently the tubular string from one of several wells on the 44-8 pad had perforated, allowing gas to escape upward through the formation and eventually venting at the surface in several adjoining locations, including the south bank of the Swanson River nearly a 1/4 mile to the north of the 44-8 pad. A "Hot Shot" crew from Texas was dispatched to Swanson River in an attempt to locate the source of the leak and bring it under control. The culprit well SCU 11-16, was finally "killed" on December 25, 1986. While some crude oil pooled to the surface on pad 44-8 during the two weeks of venting, environmental damage was minimal.

As the media reported events of the blow out, several people in the Sterling area claimed their wells had either gone dry or were contaminated. Further investigations by ADEC revealed no relationship between the Sterling wells and the blow out at Swanson River Field.

Xylene Release at Pipe and Supply Yard - 1988

In 1988, during investigations associated with the PCB remediation project, xylene contamination was discovered in soils and groundwater at the Pipe and Supply Yard within Swanson River Field.

In 1988, during investigations associated with the PCB remediation project, volatile organic compound (VOC) contamination was discovered in soils and groundwater at a supplies and materials storage site, known as the Pipe and Supply (P&S) Yard (ADEC spill number is 1988230118301).

Site characterization activities were initiated to determine the specific compounds present and the source and distribution of these compounds in the environment. VOC contamination consisted primarily of ethylbenzene, toluene, xylene and traces of benzene (collectively, BTEX). The source of contamination was apparently an aboveground tank farm within the P&S Yard, where several thousand gallons of xylene had been stored at one time. Xylene is used to inhibit the build up of asphalt in the higher temperature zones in well casings. The release of xylene was never documented, and it was never determined if the xylene release occurred as a single major catastrophic event or as a recurring leak over an extended period of time. At any rate, the release was never reported, and the quantity spilled is unknown. For general information about xylene toxicity, please see Appendix D.

Unit operator, ARCO, contracted with the consulting firm, Ecology and Environment, Inc., to complete a BTEX Risk Assessment and develop a Remedial Action Plan. Cleanup levels were established

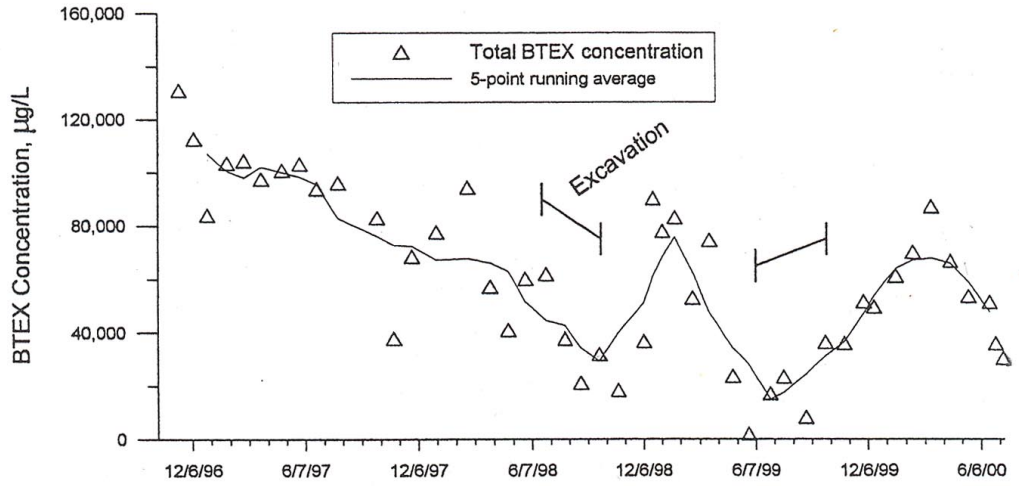
for both groundwater and soils (0.2 ppm and 1.5 ppm, respectively, for xylene) and presented for agency review and comment. The established cleanup levels were later incorporated as Amendment 5 of the Consent Order, thus directing ARCO to proceed with their remediation work.

From 1989-1992, ARCO attempted to reduce influent levels of BTEX (primarily xylene) present in excess of 100 ppm by pumping water from an intercept trench at the lower end of the affected area back through a 6" line into an air-sparging system. High iron and magnesium in the groundwater created constant maintenance problems with the air-sparging system. This, combined with the exceedingly high levels of xylene present in the groundwater, prevented any significant drop in contaminant levels. It became apparent that significant progress toward remediation only would occur by locating, excavating and treating soils saturated with xylene. The groundwater monitoring results from December 1996 to July 2000 are presented in Figure 4. The BTEX levels appear to fluctuate seasonally.

When Unocal took over the field in 1992, they began working on a new remediation plan, which included further sampling to delineate "hot spots" and an aggressive excavation plan whereby soils would be placed into "biopiles" and infused with air via a positive-flow circulating system. The first excavation of soils took place in 1995 and continued through 1998. The air-circulating system was abandoned (due to soil compacting in the biopiles) in favor of "land-farming" during the summer of 1998, where all excavated materials were spread over the area and frequently tilled using mechanical two-wing discs.

Because of the expected long-term nature of the remediation effort at the P&S Yard, Unocal is developing a plan similar to an approach used by Marathon Oil Company (Marathon) at their Poppy Lane

Figure 4. Influent Monitoring Results for the Groundwater Treatment System at the Pipe and Supply Yard at Swanson River Field from December 1996 to July 2000.



Incomplete engineered wetland at the Pipe and Supply Yard at Swanson River Field. USFWS Photo by Tiffany A. S. Parson.

site near the Kenai Gas Field (the Poppy Lane site is not on the KNWR). The plan is based on the concept of phytoremediation in an engineered wetland setting. Phytoremediation takes advantage of the nutrient utilization process used by plants, where water and nutrients are taken up through the roots, and water is transpired through the leaves. This same process is used as a transformation system to metabolize organic compounds, such as xylene. Additionally, plants stimulate soil microbes, which ultimately results in enhanced bioremediation. Bioremediation is a process where microbes breakdown organic contaminants. During summer 2000, wetland construction was completed.

A number of technical reports related to the xylene remediation project are available, including monthly reports on groundwater sampling (see Bibliography and Literature Cited).

Flare Stacks and Tank Setting Contamination - 1989

Hydrocarbon contamination discovered around flare stacks resulted in an Environmental Site Investigation for all seven tank settings and their associated gas flaring stacks. A number of soil borings were done at each site in order to determine the extent and configuration of hydrocarbon contamination. A total of 21 monitoring wells were installed around the periphery of the seven sites to establish information on possible groundwater contamination.

The following sites at Swanson River Field have elevated petroleum hydrocarbon concentrations in soil (total petroleum hydrocarbon (TPH) concentrations above 100 ppm or BTEX presence): electric shop, 243-4 mud disposal well pad, 1-4, 1-9, 1-27, 1-33, 2-15, 3-4 and 3-9 tank settings and their corresponding flare stacks and the main flare

A site assessment of each flare stack delineated the extent of crude contamination. USFWS Photo by Robert A. Richey.

stack. Additionally, groundwater contamination (total petroleum hydrocarbon (TPH) concentrations above 5 ppm or BTEX presence) exists at the following: electric shop, 1-4, 1-9, 1-27, 1-33, 2-15, 3-4 and 3-9 tank settings and 1-4, 1-9, 1-33, 2-15, 3-4 and 3-9 flare stacks. Unocal has temporarily halted their efforts on the tank settings and flare stacks pending resolution of the P&S Yard remediation project. The sites appear stable, and contamination does not appear to be migrating beyond known areas. Unocal is considering doing a risk assessment for all seven sites.

Technical reports are available (see Bibliography and Literature Cited).

Flowline Leak - 1991

On November 25, 1991, crude oil was observed just off the road right-of-way near well pad 21-22. A small pinhole leak was discovered in a 4" flowline (internal corrosion) resulting in the release of an estimated 630 gallons of crude and approximately 5,000 gallons of produced water. The contaminated area was approximately 30' by 30' in a predominately alder stand. A vacuum truck removed most of the crude within hours of the discovery, and the remaining crude was picked up by a track hoe and taken to the solid waste site on SRF. Topsoil was spread over the area, and the area was left to grow back naturally.

Flowline Break - 1994

On February 23, 1994, a 6" flowline failed due to internal corrosion near the 3-9 tank setting 1/4 mile south of the Swanson River and west of the south bridge. An estimated 2,000 gallons of crude were released mostly beneath the ground surface and within the pipeline corridor. Most of the crude was captured in the soil; approximately 200 cubic yards of material were excavated and taken to the solid waste site. Clean fill was transported to the site and dumped in the previously excavated area.

Flowline Break - 1995

On May 17, 1995, crude oil was discovered on the ground during a routine inspection on a 6" underground flowline from the 3-9 tank setting, approximately 100' north of where the line crosses the Swanson River. Crude loss was estimated at approximately 400 gallons, most of which was retrieved by a vacuum truck. A silt fence was placed immediately between the break and the Swanson River, thus preventing any further migration of oil. Because the spill event occurred in a wet boggy area near the river, the line was purged of all hydrocarbons and left in place without further excavation to prevent causing further disturbance to the wetland. The line was replaced by an aboveground line. While corrosion was suspected as the cause, the line was never excavated because of the potential for further disturbance/damage.

Flowline Break - 1999

On January 7, 1999, a flowline break was discovered when a recreational snowmobiler noticed crude pooling within the pipeline/power line right-of-way just to the west of the 1-27 tank setting

(ADEC spill number is 99239900601). Final tally of product loss was placed at 228,648 gallons; approximately 95% (217,224 gallons) was produced water and 5% (11,424 gallons) was crude oil.

Cleanup operations continued from January 8, 1999 to January 28, 1999. The majority of the crude was either extracted by vacuum trucks or excavated with a tracked hoe. Four carbon filtration dams were installed downstream from the site and a small earthen dam was constructed for skimming free product. The site was monitored daily and product vacuumed as necessary or as weather permitted. A site rehabilitation plan was developed. Hydroseeding of the site was completed by early July 1999 and revegetation is progressing.

Underground Pipeline Leak - 1999

On November 21, 1999, there was a leak in a 6" underground fiberglass pipeline used for transporting produced water to the wastewater disposal facility at tank setting 1-33. The spill occurred near the tank setting 1-4 wastewater building approximately ¼ mile from the Swanson River (ADEC spill number is 99239932501).

The spill was estimated to contain 8,600 gallons of produced water with less than one gallon of oil (ADEC, Prevention and Emergency Response Program, http://www.state.ak.us/local/akpages/ENV.CONSERV/dsparperp/unocal/status_03.htm). The produced water flowed through a culvert to an interception basin across the road. Approximately 7,000 gallons of produced water were recovered from the interception basin using a vacuum truck. The remainder of the produced water escaped the basin and flowed toward the Swanson River. Based on visual observations, the spill impact area appeared to extend to within 50' to 100' of Swanson River. Soil samples did not exceed ADEC's soil cleanup levels except for two samples closest to the spill, which exceeded the benzene cleanup levels. These locations will be resampled in the spring of 2000.

The high salt content in produced water can stress vegetation, as seen by the red leaves of this alder. USFWS Photo by James E. Frates.

Beaver Creek Field

The development of BCF began in 1967. This field is located approximately eight miles north of Soldotna, Alaska, and Marathon Oil Company (Marathon) has been the only operator of this field. A list of the major operational units at BCF is provided by Frates (pers. comm.):

> *The Beaver Creek Field, encompassing about 8 square miles, was and continues to be primarily a gas producer. It includes the following: 1,000 barrel (bbl) crude storage tank, 5,000 bbl crude storage tank, (2) 300 bbl water injection storage tanks, gas dehydration unit, 4 "T" Packs used to heat gas and separate out water, gas lift compressor, 5 pads with 6 active wells (2 oil and 4 gas), 5 miles of 12" gas transport line, numerous in-field gas gathering lines (6" and 8") and oil gathering lines (4" and 6"), 4-cell solid waste site, office and maintenance facility (one building), 1 flare stack-gas pressure relief, 2 steel support bridges crossing Beaver Creek, 2 Caterpillar natural gas-fired electrical generators [230 kilowatt (kW) and 235 kW], (1) 2,000 gal aboveground diesel fuel storage tank.*

This section details some of the major spill/contamination events that have been reported at Beaver Creek Field from 1988 to April 2000 (spill records are complete for only these years). The spill information from 1988 to 1998 was taken from a report by Frates

Beaver Creek Field Well Number 4. USFWS Photo by Tiffany A. S. Parson.

(1999b) (Appendix A). It is important to note that the number of reported spills may differ from the number of actual spills.

Major Spills and Contamination Events Reported at Beaver Creek Field

Reported Spills at Beaver Creek Field from 1988 to 1998.

42 Reported Spills
(4 spills/year average)

--2 gal percolite (corrosion inhibitor)
--3 gal hydraulic oil
--3 gal vehicle motor oil
--31 gal methanol
--163 gal triethylene glycol
--400 gal diesel fuel (single event)
--3,000 gal (plus) crude oil (2,800 gal single event)
--5,078 gal produced water

Source: Frates (1999b)

Discovery Well Blow Out - February 1967

While drilling the original discovery well in the Beaver Creek Unit, Marathon Oil Company experienced a catastrophic "blow out" when high pressure gas at the 9,300' level entered the well casing and escaped to the surface formation. The violent nature of the release sheared the well derrick from its substructure, buried equipment under 20' to 25' of formation debris and dispersed sand and gravel as far as 3/4 mile away from the rig. High pressure venting occurred for 11 days during which air traffic was diverted around the area. The well was eventually "killed" using "Hot Shot" crews from Red Adair's famous "Hell Fighters" group based in Texas. Marathon Oil abandoned the site after recovering the derrick and other supporting drilling equipment. Site restoration consisted of redistributing evicted formation material over the site, bringing top soil back over the area (saved from pad construction), fertilizing, and seeding to a mixture of native grasses and legumes.

In 1997 and 1998, a Marathon Oil employee, Charles Underwood, used this site for a Master's Thesis titled, *Surface Investigation at an Exploratory Drilling Site within the Kenai National Wildlife Refuge*. Underwood found incomplete revegetation at this site due to methane seepage. Additionally, water samples from three locations around the site revealed trace amounts of metals from drilling muds. This document is available in the KNWR library.

Tanker Rollover Spill - 1981

On November 6, 1981, a semi-tanker hauling crude slid on an icy access road while trying to avoid an oncoming truck. The semi-tanker rolled over on its side, off the road, and spilled approximately 64 bbl of crude over the ice/snow-covered peat. A vacuum truck recovered roughly 13 bbl, and recovering the remaining crude required the removal of the contaminated peat.

Tank Farm Spill - 1988

During the summer of 1988, crude oil was detected around an underground connecting flowline between a 5,000 and 1,000-bbl crude oil storage tank system near the Beaver Creek production office. Further investigation and site assessment revealed crude-saturated soils in the vicinity of the tanks. Immediately following this discovery, an attempt was made to drain the 1,000 bbl tank. To compound the problem, during the off-loading procedure a recycling hose separated, which resulted in an additional 2,800 gallons of crude oil being spilled.

Both tanks were relocated across the road from their original location, and the contaminated site was eventually excavated until sampling confirmed all traces of hydrocarbons were gone.

The excavated material (about 5,000 cubic yards) was transported to BCU Pad 7, where it was placed on an impervious liner and

Excavation of contaminated soils resulting from the tank farm spill. USFWS Photo by Robert A. Richey.

later incinerated. Periodic sampling of monitoring wells around the perimeter revealed no contamination of groundwater. The site was refilled with gravel and today is part of the industrial storage area at the Beaver Creek headquarters complex.

Technical reports are available (see Bibliography and Literature Cited).

Diesel Spill - 1990

In January of 1991, Marathon was in the process of converting their previously diesel-fired generator to natural gas. During removal of the 500-gallon aboveground diesel tank, which provided a fuel source for the generator, it was discovered that the primary fuel line from the tank to the generator (3' below the surface) had been leaking for some time. Marathon contracted with a consultant to conduct a site assessment and map the extent of the diesel plume. Because of USFWS concerns of hydrocarbons entering Beaver Creek, considerable effort was directed toward developing a better understanding of groundwater movement. Several monitoring wells were installed around the perimeter of the site and periodic groundwater samples were taken. A study conducted by Terrasat, Inc. concluded that continuous low permeability silt horizons appeared to be controlling contaminant migration above the groundwater table.

Over 1,000 cubic yards of diesel-contaminated material were excavated and transported to the Pad 7 site. The material was eventually incinerated and brought back to the site for fill.

Four wells are currently being monitored for hydrocarbon contamination, while two additional wells are designed as free product recovery wells. Free product has been recovered from the recovery wells, and the monitoring well samples suggest that contamination is not migrating from the site.

Technical reports are available (see Bibliography and Literature Cited).

Tanker Loading Spill - 1993

On January 7, 1993, while transferring crude oil from the 5,000 bbl storage facility to a tanker truck, an automatic shut-off valve failed to operate, causing approximately 120 gallons of crude to be released within the docking area. Most of the product was recovered with a vacuum truck and remaining product was mixed with sand and taken to the solid waste site.

Tanker Leak - 1993

On July 22, 1993, a 800 bbl capacity truck-tanker, owned by Jackson Construction Co., left the loading ramp with approximately 400 bbl of crude oil en route to the Tesoro Refinery. While approaching the bridge over the north fork of Beaver Creek, the driver noticed a dark mist coming from the vicinity of the tanker's forward bulkhead. When it became apparent that the mist was actually crude oil coming from a hairline crack in the forward bulkhead, the driver transferred crude to another compartment to keep the liquid below the crack. Total loss was estimated at less than 40 gallons. Personnel used shovels and buckets to retrieve contaminated gravel, which extended over a distance of approximately ¼ mile.

A 14-inch break in the forward bulkhead of this fully loaded tanker resulted in spilled crude oil along Marathon Road within the Beaver Creek Field. USFWS Photo by James E. Frates.

Summary: Oil and Gas Development

Hundreds of spills have occurred at SRF and BCF, and more spills likely will occur in the future. Many of these contamination events went unnoticed for several years to decades. It is possible that other unknown sources of contamination may exist at SRF and/or BCF. Because SRF and BCF eventually will cease operations (SRF's oil production has declined significantly over the years), it is important to determine all possible contamination threats associated with these fields prior to field closeout.

Some of the main concerns with oil and gas development include the following:

1) *unnoticed contamination events*
2) *aging flowlines and drain lines*
3) *spill potential along oil field roads*
4) *vulnerability of Swanson River and Beaver Creek to spill events*
5) *new oil and gas development*

One of the main concerns at SRF is the integrity of aging flowlines and drain lines. The SRF was established in 1957, and throughout the years many leaks/spills have occurred due to the corrosion of aging lines. Additionally as the field ages, the ratio of salt water to crude increases, and this higher salt water content expedites the corrosion of lines. The current unit operator, Unocal, is trying to remedy this situation by using chemical additives, inserting polyethylene liners into the existing flowlines and gathering lines and replacing older lines. Although the unit operators have made considerable efforts to repair/update/replace these lines and implement cathodic protection systems, the potential for leaks from aging lines still exists.

Severe corrosion in the 2-15 drain line prompted an extensive effort to determine the integrity characteristics of other long-buried lines within Swanson River Field. USFWS Photo by James E. Frates.

Another concern for both SRF and BCF is the transport of oil and other materials along the roads within and in/out of the fields. Currently at BCF, crude is transported once or twice daily to the Tesoro Refinery via tanker truck. Transporting oil and other

materials within and in/out of SRF and BCF makes these roadways vulnerable to spill events, as demonstrated by the 1981 tanker rollover spill and the 1993 tanker leak at BCF (pages 19 and 21).

Additionally, Swanson River and Beaver Creek are vulnerable to spill events because both water bodies run through the oil/gas fields and are crossed by roadways and pipelines within the fields. It should be noted that the P&S Yard, which is currently contaminated with xylene, is up gradient of the Swanson River. However, groundwater from the site is undergoing remediation. There is a down gradient interception trench, and sampling indicates xylene has not reached the river.

Swanson River and Beaver Creek are important to many fish and wildlife species and serve as spawning areas for many fish species. Sockeye salmon (*Oncorhynchus nerka*), coho salmon (*Oncorhynchus kisutch*), dolly varden (*Salvelinus malma*) and rainbow trout (*Oncorhynchus mykiss*) spawn in Swanson River, and rainbow trout spawn in Beaver Creek.

It is anticipated that new oil/gas development will occur on the refuge. Currently, 172,229 acres of coal, oil and gas and an additional 14,154 acres of entire subsurface are conveyed to Cook Inlet Region, Incorporated (CIRI). Additionally, there are 13,252 acres of Federal

Cow moose and young feeding in Swanson River below the north bridge within Swanson River Field. USFWS Photo by James E. Frates.

lease land open to coal, oil and gas development. The total acreage open to coal, oil and gas development is constantly changing due to changes in land status. For the most recent land status, please contact the USFWS Division of Reality in Anchorage, Alaska at (907) 786-3490.

One promising area for oil and gas development is the Birch Hill Unit, located nine miles north of SRF. Another area is the West Fork Gas Field, which has less development potential. Development of these and other areas likely will be accompanied by some degree of controversy, particularly where operations encroach on undisturbed habitat. A current issue at the refuge is the proposed five-mile gas pipeline from BCF to Wolf Lake. Two major pipelines already cross refuge lands. These pipelines include the underground oil pipeline from SRF to Nikiski, which extends across eight miles of refuge lands, and the Enstar underground gas pipeline from BCF to Anchorage, which extends across 38.3 miles of refuge lands.

Additional Potential Contamination Events and Sources from Oil and Gas Development

Most of the major spill events for the oil and gas fields are described in the previous sections (also see Frates 1999b in Appendix A). However, during background investigations for this report, additional potential contamination events and sources were discovered in the KNWR Annual Narratives. It is likely that this is the first time the narratives have been reviewed comprehensively from a contaminants standpoint. Given the fact that the contaminant consequences of some of the explosions, spills, etc., on the oil/gas fields were not discovered until sometimes decades after the actual event occurred, it is crucial to document all known contamination events/potential events in this document.

The most poignant example of a contamination event that went undiscovered for several years was the SRF compressor plant explosion on January 26, 1972 (see pages 9-12). For fourteen years no one realized that this explosion released PCBs (Aroclor 1248). This unnoticed contamination event resulted in the spreading of PCB contaminated soils within SRF. The PCB cleanup lasted several years and is estimated to have cost over $40 million. It was only after a baseline survey of environmental contaminants on refuges with oil and gas development that this PCB contamination was discovered. This example highlights the importance of conducting baseline contaminants monitoring on refuges with potential contamination sources.

Over 1,000 soil samples were collected in association with the extensive PCB remediation efforts at Swanson River Field. USFWS Photo by Robert A. Richey.

The following sections contain information about potential contamination events and sources at the refuge related to oil/gas activities. The following topics are addressed: drilling muds and reserve pits, injection wells, explosions, fires, transformers, mercury manometers and seismic exploration.

Drilling Muds and Reserve Pits

The contamination potential of drilling muds has generated some controversy. At drill sites, typically unlined reserve pits served as storage for drilling muds, fluids, cuttings and produced waters. New regulations adopted by ADEC in 1996 require formal closure of inactive reserve pits (also known as monofills). According to Underwood (1998), "monofills are single-use waste disposal sites that are permitted with the intent of disposing of solid wastes which are not regulated under the Resource Conservation and Recovery Act (RCRA) as a hazardous waste" (page 1). According to the EPA's RCRA Orientation Manual (http://www.epa.gov/epaoswer/general/orientat/) under Subtitle C, "Certain wastes from the exploration and production of oil, gas, and geothermal energy are excluded from the definition of hazardous waste. These wastes include those that have been brought to the surface during oil and gas exploration and production operations, and other wastes that have come into contact with the oil and gas production stream (e.g., during removal of waters injected into the drill well to cool the drill bit)."

Historically, numerous unlined reserve pits were utilized as part of oil and gas development on the Kenai National Wildlife Refuge to store drilling muds, fluids, cuttings and produced waters.

Numerous unlined reserve pits were utilized historically on KNWR, all of which were backfilled and today are difficult to locate. In 1998, ADEC inspected 68 drill sites at SRF, where reserve pits would have been located. The ADEC concluded that no apparent contamination was associated with these sites. The ADEC issued formal closure of these sites in May 1999. In 1999, the ADEC inspected 6 drills sites at BCF, where reserve pits would have been located. As of May 2000, ADEC had approved Marathon's reserve pit closure plan, although final site closure is still pending. ADEC estimates that an additional 6-8 reserve pits are located outside the current operating unit boundaries (still within the refuge boundary); these pits have not received formal closure.

A USFWS study conducted by Rodney Jackson (1990) entitled, *Report of Findings: Kenai National Wildlife Refuge Drill Mud Pilot Study*, assessed the migration potential of drill mud pit materials to surrounding soils. Jackson discovered elevated trace metal concentrations in some samples, but concluded that overall there was no gross contamination. However, drill contents buried in reserve pits still may be a potential contamination source.

The September-December 1959 Annual Narrative offers a historical perspective about the uses of reserve pits and injection wells for drill mud and liquid waste disposal:

> *It appears as though the problem of waste disposal on the Kenai National Moose Range has been surmounted. The past season's cleanup operations indicate the following methods of waste disposal to be the best according to existing site conditions:*
>
> *1) In previously constructed waste sumps (reserve pits), long, deep, narrow pits were dug, using a dragline with a clam bucket. The "jell" (drill mud) was dozed into these pits, followed by a latticework layer of downed timber and brush. Then a layer of earth, three to four feet deep, was hauled in by "Turnapulls" to seal in the mud.*

2) *In new sump construction, the sump pits are either dug long and narrow or rectangular, according to topography. Along one side of the rectangular pits, an additional long and narrow excavation is dug below the bottom level of the sump to facilitate mud disposal during cleanup.*

3) *Liquid waste requires moving before disposal of waste mud can be accomplished. On the Moose Range, a dry hole (Well No. 3) was reopened October 20, 1959, to a depth of 3,200 feet. The casing was perforated 233 feet above this level and liquid waste injected at the rate of 4,000 barrels per day at 1,000 to 1,500 pounds pressure.*
(pages 19-20)

Though reserve pits (now lined) are used less frequently today, they still are permitted and utilized in oil/gas operations on the refuge. In current operations, the majority of drilling wastes are injected underground into injection wells (discussed in the next section). Additionally, SRF and BCF each have a permitted facility for solid waste located on the refuge (page 50).

Injection Wells

Swanson River Field has five disposal wells and four enhanced recovery wells. Beaver Creek Field has two disposal wells.

As previously stated, lined reserve pits currently are used less frequently for storage of drilling muds, fluids, cuttings and produced waters. On KNWR, these substances usually are injected into 2,000+ feet deep disposal and/or enhanced recovery wells. SRF has five disposal wells and four enhanced recovery wells. BCF has two disposal wells. These wells are regulated by the Alaska Oil and Gas Conservation Commission (AOGCC) under the Underground Injection Control (UIC) program (20 AAC 25.252 and 20 AAC 25.402). Any well construction must be permitted by AOGCC. After construction, these wells are monitored regularly and tested for mechanical integrity every four years (yearly in SRF). According to the AOGCC, substances injected into enhanced recovery wells "must be appropriate for enhanced recovery and must function primarily to enhance recovery of oil and gas." These fluids include produced water, snowmelt, hydrotest fluids and treated effluent. According to AOGCC, substances injected into disposal wells must be associated with exploration and development of oil and gas and may include:

1) *any produced fluid as well as fluids circulated through a well as part of drilling, completion, workover, or maintenance activities; examples include muds and cuttings, produced sand and fluids, acids, frac fluids returned from downhole and well freeze protect fluids*

2) *fluids that have come into contact with produced fluids during normal production operations; examples include freeze protect fluids, fluids in surface lines (prior to transportation), detergents or other media used to clean vessels and lines, scale inhibitors or other chemicals added to protect surface lines, spill cleanup material and rigwash*

3) *fluids necessary to facilitate disposal of produced fluids; examples include fresh or seawater, truck rinseates, new or*

used mud, or other additives used to slurrify or otherwise treat waste prior to injection

Because these wells are monitored and regulated, contamination issues resulting from injection practices likely are minimal. However, it is necessary to document this practice as a potential contamination issue.

Explosions

In addition to the SRF compressor plant explosion (pages 9-12), some other oil/gas exploration-related explosions have occurred on the refuge. Due to the seriousness of the compressor plant explosion and the resulting unforeseen contamination issues, other explosions also may have caused unnoticed contamination issues. The explosions listed in this section were documented in the Annual Narratives. It did not appear that these explosions prompted any sort of contaminant investigation.

According to the September-December 1960 Refuge Narrative, two major explosions occurred in 1960:

> *A section of the Alaska Natural Gas Pipeline Company's pipeline ruptured during pressure testing of the completed portion of their line early in the morning of November 17th. The break occurred near the Kenai Spur Road between Soldotna and Kenai. A low, overcast sky reflected the resulting fire, lighting up the area for miles around as though it were day. The line was being tested at 1,000 pounds pressure when it gave way.*
>
> *The second explosion occurred the evening of November 26th at SRU Well 14-27 [at SRF]. During drilling operations, a pocket of gas was encountered which seeped into the drilling building before the blow-out valve was closed. The accumulated gas within the building ignited, blowing out portions of the walls and roofing. Three men were injured requiring evacuation to Anchorage.* (page 19)

Another explosion occurred on March 11, 1981 at SRF. It happened in the emergency generator/boiler room causing extensive damage to the building including electric power and alarm/shut-down systems for Plant 10 compressors.

Fires

Fires can cause contamination in a variety of ways. Fires can diminish the integrity of pipes, tanks, and other containment vessels, releasing substances stored within them. Also, substances considered to be relatively innocuous in the absence of heat may chemically transform in the presence of heat into hazardous substances (e.g., PAHs, dioxins/furans). The fires listed in this section were noted in the Annual Narratives. It did not appear that these fires prompted any sort of contaminant investigation.

Substances considered to be relatively innocuous in the absence of heat may chemically transform during explosions and fires into hazardous chemicals (e.g., PAHs, dioxins/furans).

On March 4, 1962 at SRF, a fire occurred at the SCU 41-4 tank setting causing about $2000.00 loss to dehydration equipment.

On May 27, 1965, the exhaust pipe of a large gas compressor caught fire on SRF. Damage to the building amounted to several thousand dollars.

On July 29 1968 at SRF, refuge staff discovered an unreported fire that burned nearly an acre at Soldotna Creek well site 14-9. Another inspection of SRF on August 15, 1968, located two large unreported oil spills and two unreported fires.

On December 4, 1977 at SRF, a 5,000 bbl water-holding tank collapsed due to corrosion. This incident caused a chain-reaction, which burned and destroyed three 1-33 tank setting buildings and four other tanks. In 1982, the rebuilding of the 1-33 tank setting facilities was completed. Because the 1977 Annual Narrative could not be located, further information on this explosion is not readily available.

By the late 1980s all of the PCB-containing transformers at Swanson River Field were replaced, so they no longer contained PCBs.

Transformers

Residual contamination from PCB-containing transformers may be an issue at SRF (PCB-containing transformers were not used at BCF).

At Swanson River Field on September 15, 1981, a routine inspection of field transformers revealed a transformer crack that caused about two gallons of transformer oil to leak onto the ground. The oil contained 55 ppm PCBs. The oil remaining in the transformer was drained, and the crack was repaired. Oil from a second similar transformer also was drained and replaced. The supporting concrete pad was chipped away, and the gravel was removed. All contaminated material including work clothes, tools and the oil were drummed in 19 containers and shipped outside Alaska for proper disposal. The total cost of this cleanup to the operator was $54,000.

By the late 1980s all of the PCB-containing transformers at SRF were replaced, so they no longer contained PCBs. However, residual contamination may be an issue, if any transformer oil leaked before replacement occurred.

Mercury Manometers

Residual mercury contamination from mercury manometers may be an issue at SRF (mercury manometers were not used at BCF). Manometers are instruments used to measure pressure. For general information about mercury toxicity, please see Appendix E.

As of January 2, 1991 there were 18 active and one out-of-service manometers at SRF. The manometer locations, whether or not mercury contamination was detected and the amount of mercury that was in use at each location are presented in Appendix F.
A letter by Randall B. Kanady, Cook Inlet Environmental Coordinator, to the BLM on January 2, 1991 describes the use of each manometer at SRF:

> *Manometers No. 1-15 are used to monitor compressor engine scavenger air pressure. Manometer 16 is attached to a portable control panel that is used to monitor compressor engine scavenger*

air pressure, if there is a problem with one of the first fifteen manometers. Manometer 17 is used to calibrate non-mercury flow meters. Manometer 18 is used as a level monitor on the wastewater tank at the 1-33 tank setting. Manometer 19 is an out-of-surface calibration unit stored at the electric shop.

According to this letter, minor amounts of spilled mercury were discovered at eleven manometer locations (Appendix F). As of December 12, 1990 most of the mercury was recovered. During the first quarter of 1991 all mercury manometers, except manometer 17, were replaced with non-mercury gauges at SRF. However, residual mercury contamination still may be an issue.

Seismic Exploration

Seismic exploration for detecting oil formations has been conducted over large areas of the refuge, and the refuge maintains files and reports describing the areas where seismic exploration has occurred. Seismic mapping is typically conducted by using explosives. Explosive detonations send shock waves through the rock strata, and sound waves are reflected back to the surface. These sound waves are then detected, recorded and used with geological information to determine likely oil formation locations. Seismic exploration presents more of a habitat degradation/disturbance and wildlife disturbance issue than an apparent contamination issue. However, considering the extensiveness of seismic exploration on the refuge, these operations should be noted. One issue with seismic exploration is the potential for undetonated explosive charges. On September 20, 1993, an undetonated explosive charge was discovered by a hunter along the eastern border of SRF. The charge remained from seismic explorations conducted by Northern Geophysical Company in the winter of 1989-1990.

Summary: Additional Potential Contamination Events and Sources from Oil and Gas Development

Drilling muds and reserve pits, injection wells, explosions, fires, use of PCB-containing transformers, use of mercury manometers and seismic exploration activities are examples of some historic events and past (and current) practices which may have caused some unnoticed contamination issues on the refuge. The contamination potential of these incidents should be considered and contaminants sampling should be pursued if warranted.